Smoking among Adult Congenital Heart Disease Survivors in the United States: Prevalence and Relationship with Illness Perceptions

Abstract

The relationship between smoking and illness perceptions among congenital heart disease (CHD) survivors is unknown. The primary aims of the present study were to compare the smoking prevalence among CHD survivors to a nationally representative U.S. sample and examine the relationship between smoking and illness perceptions. CHD survivors (N = 744) from six U.S. sites participated in the study. The **s**moking prevalence among CHD survivors (9.3%) was lower than the general population (15.3%). However, 23.3% of CHD survivors with severe functional limitations smoked. Smoking prevalence differed by U.S. region, with a greater proportion of those attending CHD care in the Midwest reporting smoking (11.8%). The illness perception dimensions of *Concern* and *Emotional Response* were independently associated with smoking. Differences in illness perceptions enhance our understanding of smoking among CHD survivors and may guide interventions promoting positive health behaviors. The protocol for the study from which the present analyses were conducted was recorded at ClinicalTrials.gov: NCT02150603.

Keywords: congenital heart disease, smoking, illness perceptions, tobacco, cigarettes, health behaviors

Introduction

Congenital heart disease (CHD) is the most common birth defect, affecting nearly one in 100 infants (van der Linde et al., 2011). CHD includes structural defects of varying degrees of complexity, ranging from a small opening in the heart wall to non-functional ventricles, but all require lifelong surveillance (Stout et al., 2018). Over one million adults with CHD live in the United States (Gilboa et al., 2016). This growing population, accounting for two-thirds of CHD survivors (Marelli et al., 2014), is at elevated risk for cardiovascular morbidities, including stroke (Lanz et al., 2015) and heart failure (Norozi et al., 2006). These morbidities, many of which can be mitigated by lifestyle changes, result in over $3 billion annually in hospitalizations (Opotowsky et al., 2009). Hence, behaviors that promote cardiovascular health are critical for optimizing long-term outcomes of CHD survivors.

Smoking is a major modifiable risk factor for adverse cardiovascular outcomes (Virani et al., 2020). CHD survivors who smoke have an elevated risk for numerous negative health consequences, including coronary heart disease (Bokma et al., 2018), hospitalization (Cedars et al., 2016), and premature mortality (Engelfriet et al., 2008). CHD survivors who smoke also endorse poor patient-reported outcomes, such as reduced quality of life and greater emotional distress (Moons et al., 2019). In Europe, smoking rates among CHD survivors are comparable to or lower than that observed among healthy adults (Caruana & Grech, 2016; Moons et al., 2006; Overgaard et al., 2014; Zomer et al., 2012). However, prevalence data for smoking among adult CHD survivors compared to healthy adults is in the U.S. is unknown. The frequency of smoking among adult CHD survivors presenting for emergency care is on the rise in the U.S. (Agarwal et al., 2016). This trend highlights not only the significant morbidity associated with smoking among this vulnerable population, but also the need for better understanding of the prevalence of smoking among adult CHD survivors in the U.S.

Research characterizing CHD survivors who smoke has focused primarily on demographic and psychosocial factors related to smoking among the general population (e.g., gender, education, emotional distress; Creamer et al., 2019) and has not considered disease-related factors, aside from lesion severity (Caruana & Grech, 2016; Holbein et al., 2019; Zomer et al., 2012). In particular, disease-related beliefs, such as illness perceptions, may affect smoking behavior. Illness perceptions are cognitive and emotional appraisals of illness described by the Common-Sense Model of Self-Regulation (CSM), a framework for understanding disease self-management (Leventhal et al., 2016). In brief, the CSM posits that illness perceptions develop in the context of health threats and inform patients' coping responses. Given that illness perceptions are associated with various health behaviors across disease populations, CHD survivors' beliefs about their illness may relate to smoking behavior. Among other chronic illness populations, illness perceptions (e.g., identity with one's illness, perceived helpfulness of treatment, perceived understanding of illness, emotional response to illness) are linked to engagement in health protective behaviors, such as cardiac rehabilitation participation (Broadbent et al., 2006) and medication adherence (Hayward et al., 2017). Two studies examining the relationship between illness perceptions and smoking in non-CHD samples have reported conflicting findings. Illness perceptions (e.g., stronger emotional response to illness, greater perceived control over illness) were associated with smoking abstinence among individuals with acquired heart disease (Nur, 2018), whereas there was largely no relationship observed in a study of individuals with diabetes (Petricek et al., 2009). Thus, the small body of prior research among individuals with other chronic illnesses has not clearly established the assocation of illness perceptions and smoking. Given the significant cardiovascular consequences of smoking and the potential for illness perceptions to contribute to our

understanding of this health risk behavior, it would be valuable to establish the relationship between illness perceptions and smoking status among adult CHD survivors. Establishing this relationship may inform smoking cessation and prevention interventions tailored to CHD survivors.

The present study had three aims: 1) compare the prevalence of smoking among CHD survivors to a nationally representative U.S. sample, 2) characterize the demographic and clinical profile of CHD survivors who smoke, and 3) examine the unique relationship between illness perceptions and smoking status, adjusting for demographic and clinical characteristics. Based on prior research conducted in Europe, we hypothesized that the prevalence of smoking among U.S. CHD survivors would be lower than that of the general U.S. population. Given that, according to the CSM, illness perceptions are believed to inform coping responses and that smoking is commonly perceived as a coping strategy (Klein et al., 2014), we further hypothesized that more threatening perceptions of illness (e.g., greater concern about illness, less perceived control over illness, stronger emotional response to illness) would be associated with current smoking.

Methods

Procedure

The present study is an analysis of the six U.S. centers that participated in the Assessment of Patterns of Patient-Reported Outcomes in Adults with Congenital Heart Disease-International Study (APPROACH-IS), a cross-sectional study of quality of life and other patient-reported outcomes that included 24 sites across 15 countries. The U.S. centers represented five states, namely California, Missouri, Nebraska, Ohio, and Pennsylvania. The rationale, design, and methods of APPROACH-IS have been previously described in detail (Apers et al., 2015). Inclusion criteria for APPROACH – IS were: 1) diagnosis of CHD, 2) diagnosis established prior

to adolescence, 3) ≥ 18 years of age, 4) receiving follow-up care at a CHD center included in a national or regional registry, and 5) physical, cognitive, and language abilities to complete self-report questionnaires. Exclusion criteria were: 1) prior heart transplantation, 2) isolated pulmonary hypertension, and 3) syndromes affecting cognitive abilities. Potential participants were identified by medical record review. Eligible participants were mailed a consent form and a booklet of study questionnaires or were recruited at outpatient clinics. Self-report data were collected from April 2013 to March 2015. Medical records were reviewed by medical staff, including physicians and nurses, as well as research assistants who were trained to abstract clinical data. A standardized data abstraction form and coding conventions that were operationalized in standard operating procedures were used across study sites. Moreover, data quality checks were performed in accordance with standard operating procedures followed by all study sites. The institutional review boards of the participating centers approved the study, if necessary, and all participants provided written informed consent. The study protocol for APPROACH-IS was recorded at ClinicalTrials.gov: NCT02150603. Across the U.S. centers, 752 CHD survivors participated in APPROACH-IS. Participants were included in the present analyses if they responded to an item about their smoking status, and the final sample included 744 CHD survivors from California (n = 96), Missouri (n = 67), Nebraska (n = 29), Ohio (n = 355), and Pennsylvania (n = 197).

To compare the prevalence of smoking among CHD survivors to the general U.S. population, weighted estimates from the 2013-2014 National Adult Tobacco Survey (NATS; Centers for Disease Control, 2016), which allow for representative national and state-level analyses, were analyzed. The NATS is a landline and cellular phone survey of tobacco use among adults living in the U.S. aged ≥ 18 years. To account for regional variation in smoking

status (Creamer et al., 2019), only NATS respondents from the states represented by the APPROACH-IS centers were included. As a result, the NATS subsample analyzed in this study was comprised of 13,694 adults surveyed in California (n = 6,998), Missouri (n = 1,123), Nebraska (n = 1,006), Ohio (n = 2,182), and Pennsylvania (n = 2,385). The NATS was conducted from October 2013 to October 2014, which is consistent with the APPROACH-IS data collection period. The following NATS survey item, asked of participants reporting smoking ≥100 cigarettes in their lifetime, was used to determine current smoking status: "Do you now smoke cigarettes every day, some days, or not at all?" Consistent with the Centers for Disease Control (2016) definition of current smoking, respondents who reported smoking every day or some days were considered to be individuals who smoked for the purposes of the present study. NATS respondents who endorsed current smoking were asked to provide the number of days they smoked within the past 30 days, as well as the number of cigarettes smoked per day.

Measures

Demographic and Clinical Characteristics

Demographic information, including age, sex, race, education, marital status, and employment status, was obtained by self-report. The region where participants attended CHD care was classified as Midwest (Ohio, Missouri, Nebraska), Northeast (Pennsylvania), or West (California) according to U.S. census regions (U.S. Census Bureau, 2018). Regarding clinical characteristics, New York Heart Association (NYHA) functional class was assessed by self-report such that participants reported the extent to which they experience limitations believed to be caused by their CHD during physical activity. Participants were classified as having no limitations (Class I), mild limitations (Class II), moderate limitations (Class III), or severe limitations (Class VI). Lesion severity was abstracted from medical records and was classified as

simple, moderate, or complex (Warnes et al., 2008). Additional clinical characteristics were also obtained from medical records, including number of cardiac surgeries, number of catheter interventions, history of heart failure, history of arrhythmia, and lifetime history of psychiatric disorder, including depressive, anxiety, and other disorders (e.g., eating disorder, psychotic disorder).

Smoking Behavior

A single item (i.e., "Do you smoke cigarettes occasionally or regularly?" yes/no) was used to assess current smoking status. Participants who endorsed current smoking were asked to report the number of days they smoked within the last 30 days, as well as the number of cigarettes smoked per day. For number of days smoked, the following response choices were offered: 1 to 2 days; 3 to 5 days; 6 to 9 days; 10 to 19 days; 20 to 29 days; all 30 days. For the number of cigarettes smoked per day, the following response choices were offered: 1 cigarette or less a day; 2 to 5 cigarettes a day; 6 to 10 cigarettes a day; 11 to 20 cigarettes a day; more than 20 cigarettes a day. To facilitate comparison to the NATS sample, participants who reported smoking were categorized according to the definition of low-intensity smoking (≤ 10 cigarettes per day; Inoue-Choi et al., 2017) for analysis of the number of cigarettes smoked per day.

Illness Perceptions

The Brief Illness Perception Questionnaire (BIPQ) was used to measure participants' cognitive and emotional representations of their illness (Broadbent et al., 2006). The BIPQ is composed of eight dimensions, including *Consequences* ("How much does your illness affect your life?"; n = 737), *Timeline* ("How long do you think your illness will continue?"; n = 728), *Personal Control* ("How much control do you feel you have over your illness?"; n = 733), *Treatment Control* ("How much do you feel your treatment can help your illness?"; n = 720),

Identity ("How much do you experience symptoms from your illness?"; n = 733), *Concern* ("How concerned are you about your illness?"; n = 735), *Understanding* (How well you do feel you understand your illness?"; n = 738), and *Emotional Response* ("How much does your illness affect you emotionally? (e.g., does it make you angry, scared, upset, or depressed?)"; n = 736). Each dimension is assessed with a single item, which is rated on a 0 to 10 scale. Higher scores reflect more threatening perceptions of illness for the dimensions of *Consequences, Timeline*, *Identity*, *Concern*, and *Emotional Response*, whereas lower scores on *Personal Control*, *Treatment Control*, and *Understanding* indicate more threatening perceptions of illness.

Statistical Analysis

Descriptive statistics were used to characterize the demographic and medical status profile of the sample. To address our first aim, a chi-square analysis was performed to compare the proportion of smoking among CHD survivors to the proportion of smoking among the general U.S. population. In addition, chi-square analyses were used to compare the smoking frequency and intensity of CHD survivors and adults in the general population. Regarding our second aim, *t*-test and chi-square analyses were conducted to identify demographic and clinical differences on smoking status. To quantify the magnitude of the relationships examined in our first two aims, effect sizes were calculated for t-tests (Cohen's *d*) and chi-square (φ, Cramer's *V*) analyses. With respect to our third aim, a series of unadjusted eight logistic regressions were conducted to determine the association between the illness perception dimensions and current smoking. For illness perception dimensions significantly associated with current smoking ($p \leq .05$) in unadjusted models, hierarchical logistic regressions analyses were performed to determine the unique association of illness perception dimensions and current smoking status. Based on our prior work (Holbein et al., 2019; Moons et al., 2019), as well as research

identifying factors associated with smoking status in the general population (Creamer et al., 2019), all assessed demographic and clinical characteristics were entered in the regression model as covariates.

Results

Aim 1: Smoking Prevalence and National Comparison

Among CHD survivors, 9.3% currently smoked, while 15.3% of adults in the general population from the same states currently smoked, $\chi^2(1, N = 14{,}350) = 98.17$, $p < .001$, $\varphi = 0.08$. Of CHD survivors who smoke, 44.9% reported daily smoking during the last 30 days. Comparatively, 76.1% of adults who smoke from the same states smoked daily during the last 30 days, $\chi^2(1, N = 1{,}806) = 34.34$, $p < .001$, $\varphi = 0.14$. Three quarters of CHD survivors who smoked (75.4%) reported smoking 10 or fewer cigarettes per day (i.e., low intensity smoking), whereas half of those from the same states who smoked (53.9%) reported smoking 10 or fewer cigarettes per day, $\chi^2(1, N = 1{,}350) = 12.17$, $p < .001$, $\varphi = 0.09$.

Aim 2: Smoking Status According to Demographic and Clinical Characteristics

Demographic and clinical characteristics are presented in **Table 1.** CHD survivors who smoked were younger, $t(97.31) = 2.04$, $p = .045$, $d = 0.22$, and less likely to have a college education, $\chi^2(1, N = 737) = 5.81$, $p = .016$, $\varphi = 0.09$, compared to those who did not smoke. Smoking status differed by geographic region, $\chi^2(2) = 10.29$, $p = .006$, $V = 0.12$, with a greater proportion of those who smoked attending CHD care in the Midwest (11.8%) than the West (2.1%), $p = .004$, $\varphi = 0.12$.

In terms of clinical characteristics, there were no differences between those who smoked and those who did not smoke on lesion severity, but smoking status differed according to NYHA functional class, $\chi^2(3, N = 716) = 15.35$, $p = .002$, $V = 0.15$. Bonferroni-corrected pairwise

comparisons indicated that CHD survivors who endorsed limitations consistent with NYHA Class IV (23.3%) were more likely to smoke than those who endorsed limitations consistent with Class I (7.7%), $p < .001$, $\varphi = 0.19$, Class II (8.9%), $p = .002$, $\varphi = 0.18$, or Class III (7.5%), $p = .012$, $\varphi = 0.22$. CHD survivors who smoked had fewer catheter interventions than those who did not smoke, $t(105.93) = 2.75$, $p = .007$, $d = 0.28$, and were more likely to have a history of psychiatric disorder compared to those who did not smoke, $\chi^2(1, N = 739) = 12.66$, $p < .001$, $V = 0.13$ (see **Table 1**).

Aim 3: Association of Illness Perceptions and Current Smoking

In unadjusted models, the illness perception dimensions of *Concern* (OR = 1.10, 95% CI [1.02, 1.20], $p = .019$), *Emotional Response* (OR = 1.17, 95% CI [1.09, 1.27], $p < .001$), *Identity* (OR = 1.14, 95% CI [1.05, 1.24], $p = .002$), and *Consequences* (OR = 1.09, 95% CI [1.01, 1.19], $p = .034$) were associated with increased odds of current smoking. In contrast, greater *Personal Control* (OR = 0.92, 95% CI [0.84, 1.00], $p = .043$) and *Treatment Control* (OR = 0.90, 95% CI [0.82, 0.99], $p = .029$) were associated with decreased odds of current smoking. The dimensions of *Understanding* (OR = 0.90, 95% CI [0.81, 1.01], $p = .065$) and *Timeline* (OR = 1.01, 95% CI [0.91, 1.12], $p = .913$) were not related to current smoking.

To determine the unique association of illness perceptions and current smoking, a series of hierarchical logistic regression was conducted. Demographic and clinical covariates were entered in the first block, and illness perception dimensions were entered in the second block. Based on the results of the unadjusted models, six hierarchical logistic regression models were analyzed for the illness perception dimensions of *Concern*, *Emotional Response*, *Identity*, *Consequences*, *Personal Control*, and *Treatment Control*. The addition of the illness perception dimension of *Concern* in the second block of the regression significantly improved model fit,

$\chi^2(1) = 4.14$, $p = .042$, and the overall model remained significant, $\chi^2(20) = 51.92$, $p < .001$. Adjusting for demographic and clinical covariates, CHD survivors with greater concern about their illness had greater odds of smoking (OR = 1.11, 95% CI [1.00, 1.22], $p = .045$) (see **Table 2**). Similarly, the addition of the illness perception dimension of *Emotional Response* in the second block of the model significantly improved model fit, $\chi^2(1) = 8.01$, $p = .005$, and the overall model remained significant, $\chi^2(20) = 56.10$, $p < .001$. CHD survivors who endorsed greater emotional impact (e.g., feeling angry, sad, upset, or depressed) of their illness had increased odds of current smoking (OR = 1.15, 95% CI [1.04, 1.27], $p = .005$), controlling for demographic and clinical factors (see **Table 2**). The illness perception dimensions of *Identity*, (OR = 1.11, 95% CI [0.97, 1.26], $p = .121$), *Consequences*, (OR = 1.07, 95% CI [0.94, 1.21], $p = .341$), *Personal Control*, (OR = 0.94, 95% CI [0.85, 1.03], $p = .193$), and *Treatment Control*, (OR = 0.91, 95% CI [0.82, 1.01], $p = .074$), were not associated with current smoking, adjusting for demographic and clinical characteristics.

Discussion

As life expectancies for individuals with CHD increase (Khairy et al., 2010), CHD survivors remain at elevated risk for cardiovascular morbidity (Harris et al., 2018), signifying the importance of lifestyle modifications to promote positive long-term outcomes. The present study contributes to our understanding of health behaviors among CHD survivors by identifying rates of smoking as compared to the general U.S. population, as well as factors associated with smoking, a cardiovascular risk factor associated with numerous health consequences.

In the present study, the prevalence of smoking among CHD survivors was lower than a sample of the U.S. general population, accounting for regional variation in smoking status. This finding is consistent with studies of European samples that reported lower rates of smoking

among CHD survivors compared to healthy controls (Caruana & Grech, 2016; Moons et al., 2006; Zomer et al., 2012). The prevalence of daily smoking was also lower among CHD survivors than the general population, and CHD survivors who smoked were more likely to smoke at a low intensity (≤ 10 cigarettes per day) compared to adults who smoke in the general population. Others have also found that CHD survivors who smoke are less likely to smoke on a daily basis than those who smoke among the general population (Caruana & Grech, 2016). Despite reporting intermittent smoking patterns, CHD survivors who smoke are at risk for the same negative health consequences of smoking as those who smoke in the general population (U.S. Department of Health and Human Services, 2014), underscoring the harmful effects of low-intensity smoking (Inoue-Choi et al., 2017).

CHD survivors may be less likely to smoke due to belief that smoking is more harmful for individuals with CHD than healthy individuals (Van Deyk et al., 2010). In addition, smoking is a behavior that is generally established during adolescence (U.S. Department of Health and Human Services, 2014), and differences in psychosocial adaptation, such as parental overprotection (Linde et al., 1966), poorer peer relationships (Schaefer et al., 2013), and dependent living status (Kokkonen & Paavilainen, 1992), between adolescents and young adults with CHD and healthy individuals may affect the uptake of smoking. Alternatively, CHD survivors may be particularly reluctant to report engaging in health risk behaviors, such as smoking, and the true extent of smoking behavior in this population may be underestimated. The prevalence of smoking according to self-report has been found to be comparable to the prevalence of smoking determined by biochemical measurement in a population-based study of adults (Caraballo et al., 2001). However, elevated rates of underreporting have been observed in populations for which smoking may be viewed as particularly socially undesirable, including

adult survivors of childhood cancer (Huang et al., 2018), acquired heart disease patients (Gerritsen et al., 2015), and pregnant women (Britton et al., 2004). It also must be noted that the assessment of current smoking status differed between CHD survivors and NATS respondents. NATS respondents were asked about current smoking only if they endorsed a lifetime history of smoking 100 cigarettes or more, while all CHD survivors were asked about current smoking.

Consistent with the national profile of adults who smoke, CHD survivors who smoked reported lower educational attainment than those who did not smoke and were more likely to attend CHD care in the Midwest, which has a higher smoking rate than other regions (Creamer et al., 2019). There were no differences in smoking prevalence according to gender, race, or marital status, although differences in smoking prevalence on these demographic characteristics have been observed in the general population (Creamer et al., 2019). It is uncertain whether these demographic differences are not present among CHD survivors, or whether the small number of CHD survivors who smoked in this study limited the detection of significant differences. Our sample of CHD survivors was recruited from patients engaged in follow-up care, and thus may not reflect the demographic profile of all CHD survivors who smoke in the U.S.

With respect to clinical status, the proportion of CHD survivors who smoked did not differ according to lesion severity. This finding is inconsistent with other research, that observed relationships between smoking status and lesion severity such that the prevalence of smoking among CHD survivors with mild lesions is higher than among those with severe lesions (Caruana & Grech, 2016; Zomer et al., 2012). While the prevalence of smoking did not differ according to lesion severity, smoking did differ according to NYHA functional class. Nearly a quarter of CHD survivors who endorsed functional limitations consistent with NYHA Class IV reported smoking, while less than 10% of participants with better functional capacity reported smoking.

Moreover, NYHA Class IV limitations were associated with current smoking in the presence of demographic and clinical characteristics and dimensions of illness perceptions. However, although the proportion of CHD survivors who smoke with severe functional limitations was higher than smoking among the general population as represented in this study, it reflects only a small number of CHD survivors (n = 14). Additionally, given the cross-sectional design, the direction of the relationship between functional limitations and smoking status cannot be ascertained. Smoking may have preceded or possibly contributed to functional limitations, or CHD survivors with severe functional limitations may be less likely to view smoking as a threat to their health. Regardless of the direction, this finding indicates that a considerable portion of CHD survivors with severe functional limitations may be at risk for smoking.

NYHA functional class was assessed by self-report in this study, and participants were instructed to consider only limitations believed to be attributable to their CHD. Therefore, poor perceived health status may not be sufficient motivation for smoking cessation. This finding also highlights the difficulties of achieving and maintaining smoking cessation in the context of chronic illness. Individuals who smoke and believe that smoking has damaged their health are more likely to have had a history of at least one quit attempt but also report lower self-efficacy for quitting smoking compared to individuals who smoke and do not believe smoking has damaged their health (Li et al., 2019). Moreover, while rates of smoking cessation increase after an acute medical event (i.e., myocardial infarction, stroke) or diagnosis of a chronic illness (i.e., cancer, diabetes), the likelihood of cessation is greater among those having experienced acute events. However, cessation declines to rates consistent with those observed among healthy individuals for both groups over time (Twardella et al., 2006). Furthermore, smoking has declined among healthy individuals in recent years, but the prevalence of smoking among those

with chronic health conditions has remained stable (Stanton et al., 2016). Thus, it is important to identify disease-related factors associated with smoking that may perpetuate poor health behaviors and could be viable targets for intervention.

One disease-related factor that may enhance our understanding of smoking behavior among CHD survivors is illness perceptions. In the present study, unadjusted models indicated that greater *Concern*, *Emotional Response*, *Identity*, and *Consequences* were associated with increased odds of smoking, whereas greater *Personal Control* and *Treatment Control* were associated with decreased odds of smoking. CHD survivors who smoke are more likely to experience morbidities than those who do not smoke (Bokma et al., 2018), and these negative health consequences may have informed the illness perceptions of the those who smoke in this sample. For example, CHD survivors with morbidities may experience greater concern about their illness and feel more emotionally affected by their illness. Conversely, illness perceptions may have contributed to the uptake or maintenance of smoking behavior, a notion consistent with the CSM. Threatening perceptions of illness, such as greater concern about CHD, lower perceived benefit of treatment, and greater emotional impact of CHD, may have prompted CHD survivors with these beliefs to adopt coping strategies, which may include smoking. Emotional distress, an established predictor of smoking onset (Wellman et al., 2016), is associated with illness perceptions (e.g., stronger emotional representation of illness, greater concern about illness, lower perceived control over illness) among CHD survivors (O'Donovan et al., 2016). Moreover, among individuals who smoke cigarettes, smoking is perceived to help manage anger, worry, and nervousness (Klein et al., 2014). Thus, CHD survivors with greater emotional distress related to their illness may be more likely to engage in smoking to cope with these concerns. Indeed, the present findings demonstrate that the illness perception dimensions reflecting

emotional representations of illness (i.e., *Concern* and *Emotional Response*), specifically, were related to current smoking. Moreover, CHD survivors with a history of psychiatric disorder were more likely to smoke.

Importantly, dimensions of illness perceptions were related to smoking controlling for demographic and clinical characteristics such that increasingly greater concern about one's illness and increasingly greater emotional impact of one's illness were associated with greater odds of smoking. If longitudinal research were to establish that dimensions of illness perceptions precede the onset of smoking among CHD survivors, the BIPQ may be useful for identifying those with elevated risk for smoking and who may benefit from referral to appropriate education or intervention programs. In addition, illness perceptions are a conceivable target of smoking cessation interventions for CHD survivors who have already established smoking behavior. Illness perceptions are amenable to psychosocial intervention, particularly the degree of control patients feel regarding their medical treatment and understanding of their illness (Broadbent et al., 2015). For example, a brief intervention informed by illness perceptions delivered to non-adherent patients taking cardiovascular or hypoglycemic medications was associated with increased perceived treatment control and understanding of illness six months post-intervention, as well as improved self-reported medication adherence (Nguyen et al., 2016). Although it is uncertain if the improved adherence observed in this study was attributable to increased treatment control and illness understanding, this research indicates that behavioral change can co-occur with changes in illness perceptions. Hence, illness perceptions may inform smoking cessation interventions tailored to CHD survivors with the goal of improving cardiovascular health. Furthermore, in a study of patients presenting with non-cardiac chest pain or benign palpitations, concern about one's illness and the emotional effect of illness were reduced among

those receiving a three-session cognitive-behavioral intervention compared to those receiving treatment as usual (Jonsbu et al., 2013). Thus, the illness perception dimensions related to smoking in the present study are potentially modifiable targets of intervention and may inform smoking prevention/cessation programming for CHD survivors. Cardiologists routinely assess smoking status but approximately one-third of cardiologists report low awareness or lack of available resources as a barrier to cessation referral (Aboyans et al. 2009; Meijer et al., 2019), highlighting the need for interventions tailored to CHD survivors.

Limitations

While this study has several strengths, including a large sample of CHD survivors drawn from six centers representing three geographical regions in the United States, the findings should be interpreted in the context of some limitations. First, the cross-sectional design of this study precludes inferences about the temporal relationship between smoking status and illness perceptions. A longitudinal study of adolescent CHD survivors would be the optimal design to characterize the relationship between illness perceptions and smoking. Second, there was a small number of CHD survivors who smoked in this study, the sample was composed of primarily White CHD survivors, and no participants were recruited from CHD centers in the Southern U.S. In addition, there was only one center located in each the Western and Northeastern census regions, and the distribution of the CHD sample across the census regions is not reflective of the distribution of the U.S. population. These considerations may limit the extent to which the findings can be generalized to the population of CHD survivors in the U.S. at large. Similarly, the CHD survivors in this study received follow-up care at a CHD center and may not be representative of adult CHD survivors who are not receiving care a CHD center. Adult CHD survivors receiving care outside of a CHD center or that are no longer engaged in follow-up care

may have significantly different perceptions of their illness, as well as engage in different health behaviors. Next, smoking status was assessed by self-report, which may have underestimated the prevalence of smoking among CHD survivors. Additionally, the questions used to assess smoking status and frequency among CHD survivors are not consistent with those used in the NATS and other surveys of the smoking behavior of U.S. adults, which may limit the comparison of the current findings to other research. Data for this study was collected in 2013 – 2015 and may not reflect recent trends in smoking and nicotine use. For example, and this study did not consider, e-cigarettes which have rapidly increased in popularity among both adults who do and do not smoke (McMillen et al., 2015). In addition, other forms of tobacco, including cigars and smokless tobacco, which may also present a health risk to CHD survivors, were not assessed. Finally, the number of CHD survivors represented in the NATS sample is unknown. We expect that this number would reflect the prevalence rate of CHD, indicating that approximately 1% of participants in the NATS sample may have some form of CHD. Finally, it is noted that the BIPQ assess only negative reactions to one's illness for certain illness perception dimensions (e.g., *Emotional Response*, *Consequences*) and that perceived benefits of one's illness were not measured.

Future Directions

The present study provided a comparison of self-reported smoking rates among CHD survivors to that of a national sample in the same geographic regions, as well as preliminary evidence regarding the relationship between smoking and illness-related beliefs among CHD survivors. While smoking was less prevalent among CHD survivors than the general population, nearly one in 10 adult CHD survivors smoke, highlighting the need for continued efforts to reduce this behavior in this at-risk population. As most smoking behavior is initiated in

adolescence (U.S. Department of Health and Human Services, 2014), programs to discourage this health risk behavior should begin in pediatric CHD settings and extend into adult CHD care.

Given the observed positive association between illness perceptions and the major cardiovascular risk factor of smoking, future research is warranted to further describe this relationship. Longitudinal research should be undertaken to identify the relationship between illness perceptions and smoking onset, as well as other behaviors detrimental to cardiovascular health. Research delineating the smoking risk perceptions of CHD survivors may also advance our understanding of smoking behavior in this population. In the context of this work, future research should aim to increase diversity represented in samples of CHD survivors, particularly given the racial and ethnic disparities present in smoking cessation (Fu et al., 2008). Illness perceptions may also be investigated as targets of intervention to promote positive health behaviors among CHD survivors, thereby reducing morbidity and enhancing quality of life among this vulnerable and growing population.

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Table 1. Demographic and clinical comparison of CHD survivors according to smoking status reported as % (N) for categorical variables and *M(SD)* for continuous variables.

		All (N = 744)	Current smoking (n = 69)	No smoking (n = 675)
Demographic Characteristics				
Sex (n = 741)	Female	59.1% (438)	66.2% (45)	58.4% (393)
	Male	40.9% (303)	33.8% (23)	41.6% (280)
Race (n = 740)	White	90.4% (699)	91.3% (63)	90.3% (606)
	Non-White	9.6% (71)	8.7% (6)	9.7% (65)
Age* (n = 743)		34.0 (12.2)	31.9 (9.0)	34.3 (12.5)
Education* (n = 737)	≤ High school	46.4% (342)	60.3% (41)	45.0% (301)
	> High school	53.6% (395)	39.7% (27)	55.0% (368)
Marital status (n = 740)	Married/partner	48.9% (362)	40.3% (27)	49.8% (335)
	Other	51.1% (378)	59.7% (40)	50.2% (338)
Employment status (n = 738)	Full/part time	69.1% (510)	63.8% (44)	69.7% (466)
	Other	30.9% (228)	36.2% (25)	30.3% (203)
U.S. census region** (n = 744)	Midwest	60.6% (451)	76.8% (53)	59.0% (398)
	Northeast	26.5% (197)	20.3% (14)	27.1% (183)
	West	12.9% (96)	2.9% (2)	13.9% (94)
Clinical Characteristics				
Lesion severity (n = 744)	Simple	17.6% (131)	20.3% (14)	17.3% (117)
	Moderate	48.1% (358)	53.6% (37)	47.6% (321)
	Complex	34.3% (255)	26.1% (18)	35.1% (237)
NYHA functional class** (n = 716)	Class I	49.2% (352)	40.3% (27)	50.1% (325)
	Class II	33.1% (237)	31.3% (21)	33.3% (216)
	Class III	9.4% (67)	7.5% (5)	9.6% (62)
	Class IV	8.4% (60)	20.9% (14)	7.1% (46)
Cardiac surgeries (n = 743)		2.1 (1.5)	1.8 (1.3)	2.1 (1.1)
Catheter interventions** (n = 742)		0.9 (1.5)	0.6 (1.0)	0.9 (1.5)
Heart failure (n = 702)	Current	6.6% (46)	1.5% (1)	7.1% (45)
	Past	8.3% (58)	10.3% (7)	8.0% (51)
	Never	85.2% (598)	88.2% (60)	84.9% (538)
Arrhythmia (n = 737)	Yes	38.0% (280)	37.7% (26)	38.0% (254)
	No	62.0% (457)	62.3% (43)	62.0% (414)
Psychiatric disorder** (n = 739)	Yes	21.4% (158)	38.2% (26)	19.7% (132)
	No	78.6% (581)	61.8% (42)	80.3% (539)

*$p < 0.05$; **$p < 0.01$. Abbreviation: NYHA, New York Heart Association

Table 2. Final blocks of logistic regression results of the odds of current smoking among CHD survivors for the illness perceptions dimensions of *Concern* and *Emotional Response*.

		OR	95% CI	*p*
Concern	Sex[a]	1.05	0.57, 1.91	.883
	Race[b]	0.99	0.35, 2.79	.984
	Age	0.97	0.94, 1.00	.063
	Education[c]	0.65	0.34, 1.22	.182
	Marital status[d]	0.81	0.45, 1.47	.483
	Employment status[e]	1.49	0.75, 2.93	.252
	U.S. census region, Northeast[f]	0.73	0.35, 1.56	.426
	U.S. census region, West[f]	0.12	0.02, 1.01	.051
	Lesion severity, moderate[g]	1.08	0.50, 2.34	.852
	Lesion severity, complex[g]	0.72	0.29, 1.84	.497
	NYHA Class II[h]	1.08	0.54, 2.17	.826
	NYHA Class III[h]	1.24	0.39, 3.94	.718
	NYHA Class IV[h]	4.04	1.44, 11.35	.008
	Cardiac surgeries	0.81	0.64, 1.02	.078
	Catheter interventions	0.78	0.56, 1.09	.141
	Heart failure, current[i]	0.17	0.02, 1.36	.095
	Heart failure, past[i]	1.52	0.55, 4.17	.416
	Arrhythmia[j]	1.36	0.71, 2.58	.352
	Psychiatric disorder[k]	1.68	0.88, 3.19	.115
	Concern	1.11	1.00, 1.22	.045
Emotional Response	Sex[a]	1.00	0.55, 1.82	.992
	Race[b]	0.92	0.32, 2.60	.871
	Age	0.97	0.94, 1.00	.085
	Education[c]	0.64	0.34, 1.20	.160
	Marital status[d]	0.84	0.46, 1.52	.564
	Employment status[e]	1.62	0.82, 3.19	.165
	U.S. census region, Northeast[f]	0.75	0.35, 1.60	.463
	U.S. census region, West[f]	0.13	0.02, 1.04	.054
	Lesion severity, moderate[g]	1.11	0.51, 2.42	.799
	Lesion severity, complex[g]	0.71	0.28, 1.81	.478
	NYHA Class II[h]	0.95	0.46, 1.96	.895
	NYHA Class III[h]	1.05	0.32, 3.39	.938
	NYHA Class IV[h]	3.29	1.15, 9.46	.027
	Cardiac surgeries	0.80	0.63, 1.01	.055
	Catheter interventions	0.77	0.55, 1.08	.133
	Heart failure, current[i]	0.17	0.02, 1.37	.095
	Heart failure, past[i]	1.52	0.55, 4.18	.416
	Arrhythmia[j]	1.33	0.70, 2.54	.382
	Psychiatric disorder[k]	1.40	0.72, 2.70	.319
	Emotional response	1.15	1.04, 1.27	.005

[a] Male sex is the reference category; [b] Non-White race is the reference category; [c] ≤ High school is the reference category; [d] Not married or living with a partner is the reference category; [e] Not working full/part time is the reference category; [f] Midwest is the reference category; [g] Simple lesion severity is the reference

category; [h] NYHA I is the reference category; [i] No history of heart failure is the reference category; [j] No history of arrhythmia is the reference category; [k] No history of psychiatric disorder is the reference category. Abbreviations: OR, odds ratio; CI, confidence interval; NYHA, New York Heart Association